Calibration Laboratory of Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland

PC Test

Reference 20 dB Attenuator

Reference Probe EX3DV4

Secondary Standards

DAE4

Type-N mismatch combination

Client



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage С

S

Servizio svizzero di taratura

S Swiss Calibration Service

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Accreditation No.: SC	25 0108	3
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Certificate No: D1900V2-5d080 Oct18

Apr-19

Apr-19

Dec-18

Oct-19

Scheduled Check

GALIBRATION	CERTIFICA	le	
Object	D1900V2 - SN	:5d080	
Calibration procedure(s)	QA CAL-05.v1 Calibration pro	0 cedure for dipole validation kits ab	ove 700 MHz
Calibration date:	October 23; 2	018	BN^{\prime} 10-30-2018 BN^{\prime} inits of measurements (SI). 10-20-2
	•	national standards, which realize the physical u se probability are given on the following pages a	
All calibrations have been cor	nducted in the closed labor	ratory facility: environment temperature (22 \pm 3)	
Calibration Equipment used (M&TE critical for calibratic	n)	
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19

Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	in house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19
	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
			EN
Approved by:	Katja Poković	Technical Manager	COR
			Issued: October 23, 2018

04-Apr-18 (No. 217-02682)

04-Apr-18 (No. 217-02683)

Check Date (in house)

30-Dec-17 (No. EX3-7349_Dec17)

04-Oct-18 (No. DAE4-601_Oct18)

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

SN: 5058 (20k)

SN: 7349

SN: 601

ID #

SN: 5047.2 / 06327

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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Glossary:

TO	Atomical advantation of Hanviel
TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end • of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed • point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	VJZ.10.2
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.3 ± 6 %	1.40 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.93 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.8 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.18 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.9 ± 6 %	1.47 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.62 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.5 Ω + 7.9 jΩ
Return Loss	- 21.8 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.1 Ω + 8.1 jΩ
Return Loss	- 21.5 dB

General Antenna Parameters and Design

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	June 28, 2006

DASY5 Validation Report for Head TSL

Date: 23.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d080

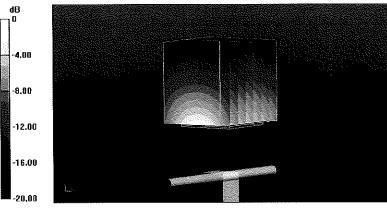
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.4$ S/m; $\varepsilon_r = 40.3$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.18, 8.18, 8.18) @ 1900 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

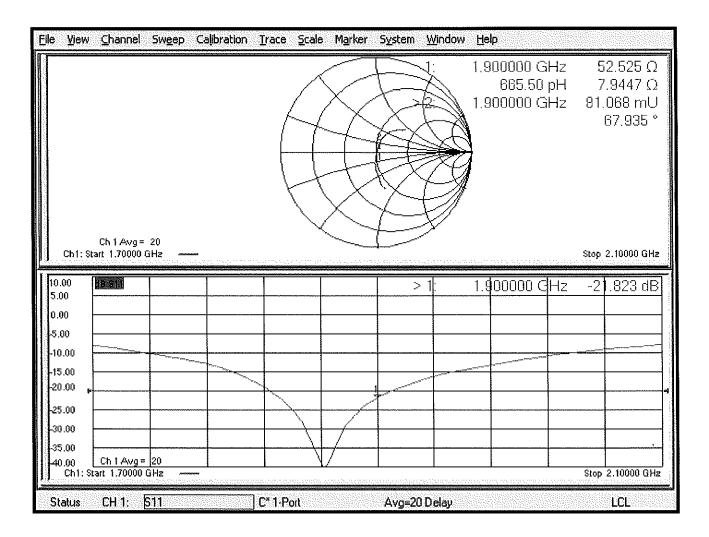
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.0 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 18.7 W/kg SAR(1 g) = 9.93 W/kg; SAR(10 g) = 5.18 W/kg Maximum value of SAR (measured) = 15.6 W/kg



0 dB = 15.6 W/kg = 11.93 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 23.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d080

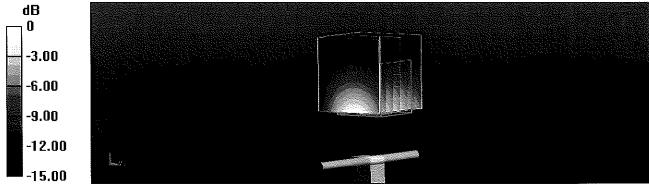
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; σ = 1.47 S/m; ϵ_r = 52.9; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

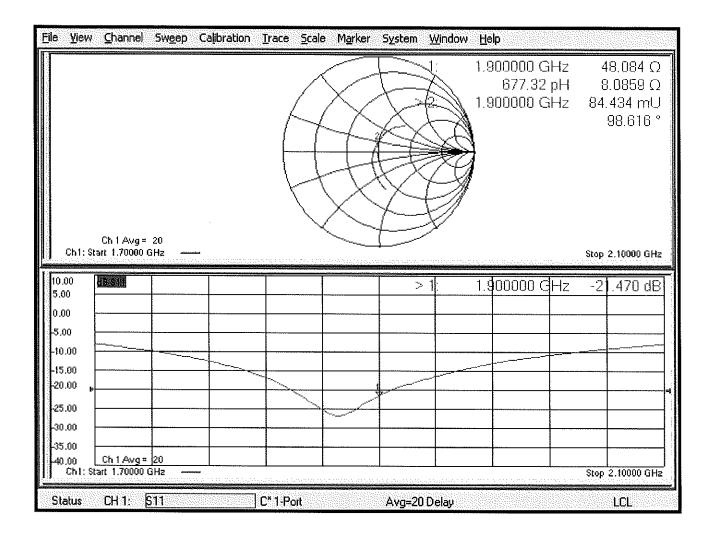
- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15) @ 1900 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 99.86 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 17.3 W/kg SAR(1 g) = 9.62 W/kg; SAR(10 g) = 5.09 W/kg Maximum value of SAR (measured) = 14.1 W/kg



0 dB = 14.1 W/kg = 11.49 dBW/kg





PCTEST ENGINEERING LABORATORY, INC. 7185 Oakland Mills Road, Columbia, MD 21046 USA Tel. +1.410.290.6652 / Fax +1.410.290.6654

http://www.pctest.com



Certification of Calibration

Object

D1900V2 - SN:5d080

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

October 18, 2019

Extended Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181334684
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable Dielectric Assessment Kit	8/13/2019	Annual	8/13/2020	1041
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008
Anritsu	ML2495A	Power Meter	11/20/2018	Annual	11/20/2019	1039008
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk	NC-100	Torque Wrench	5/9/2018	Biennial	5/9/2020	22217
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	2/19/2019	Annual	2/19/2020	3914
SPEAG	EX3DV4	SAR Probe	5/16/2019	Annual	5/16/2020	7406
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2019	Annual	5/8/2020	859
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/14/2019	Annual	2/14/2020	1272

Note: CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path.

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Team Lead Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK

Object:	Date Issued:	Page 1 of 4
D1900V2 – SN: 5d080	10/18/2019	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

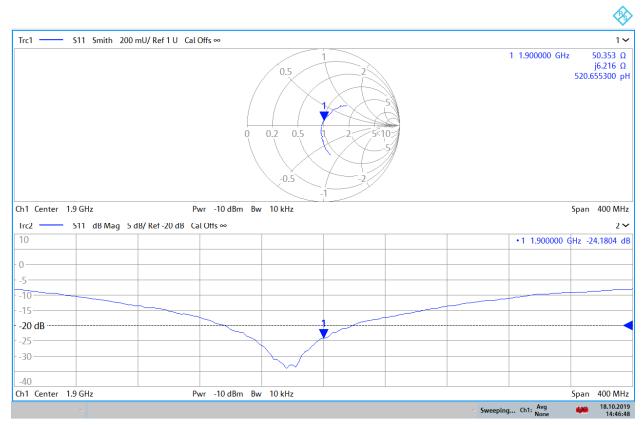
- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(96)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2019	1.193	3.98	4.16	4.52%	2.07	2.13	2.90%	52.5	50.4	2.1	7.9	6.2	1.7	-21.8	-24.2	-10.90%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2019	1.193	3.92	4.21	7.40%	2.06	2.16	4.85%	48.1	46.5	1.6	8.1	6.6	1.5	-21.5	-22.2	-3.40%	PASS

Object:	Date Issued:	Dogo 2 of 4
D1900V2 – SN: 5d080	10/18/2019	Page 2 of 4

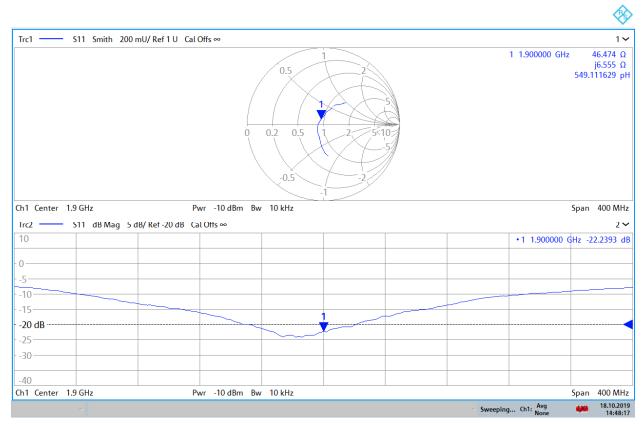
Impedance & Return-Loss Measurement Plot for Head TSL



14:46:49 18.10.2019

Object:	Date Issued:	Page 3 of 4
D1900V2 – SN: 5d080	10/18/2019	Fage 5 01 4

Impedance & Return-Loss Measurement Plot for Body TSL



14:48:18 18.10.2019

Object:	Date Issued:	Page 4 of 4
D1900V2 – SN: 5d080	10/18/2019	Fage 4 01 4





Certification of Calibration

Object

D1900V2 - SN: 5d080

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

10/18/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description		Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	11/29/2018	Biennial	11/29/2020	181766816
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	9/29/2020	Annual	9/29/2021	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
Anritsu	MA2411B	Pulse Power Sensor	8/12/2020	Annual	8/12/2021	1207364
Anritsu	MA2411B	Pulse Power Sensor	9/22/2020	Annual	9/22/2021	1315051
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	5/13/2020	Annual	5/13/2021	MY47420603
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	3/18/2020	Annual	3/18/2021	7526
SPEAG	EX3DV4	SAR Probe	12/11/2019	Annual	12/11/2020	7570
SPEAG	DAE4	Dasy Data Acquisition Electronics	12/18/2019	Annual	12/18/2020	859
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/12/2020	Annual	3/12/2021	1368

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Dogo 1 of 4	
D1900V2 – SN: 5d080	10/18/2020	Page 1 of 4	

DIPOLE CALIBRATION EXTENSION

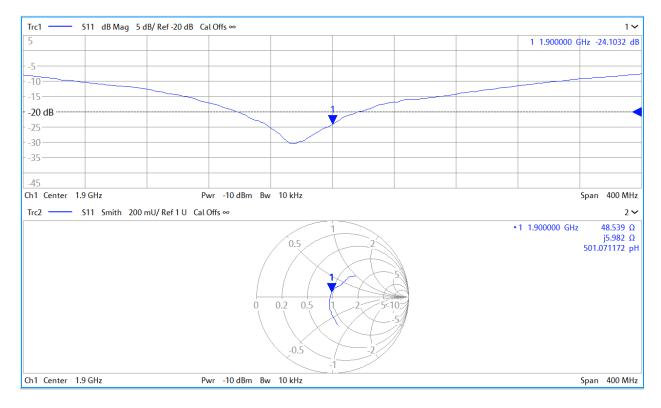
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

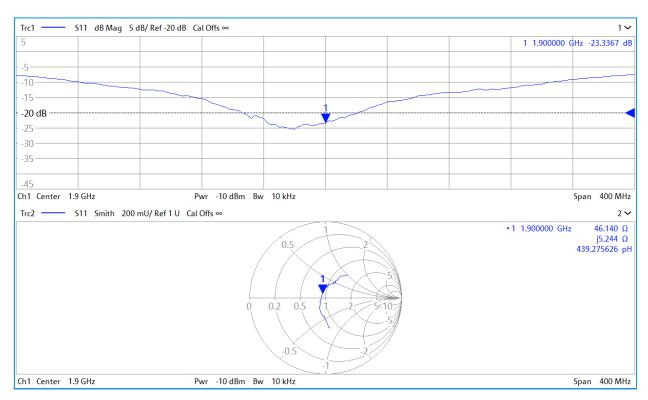
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Head SAR (1g) W/kg @ 20.0 dBm	(9()	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2020	1.193	3.98	4.01	0.75%	2.07	2.05	-0.97%	52.5	48.5	4	7.9	6	1.9	-21.8	-24.1	-10.60%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2020	1.193	3.92	4.24	8.16%	2.06	2.18	5.83%	48.1	46.1	2	8.1	5.2	2.9	-21.5	-23.3	-8.50%	PASS

Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d080	10/18/2020	Fage 2 01 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Dogo 2 of 4
D1900V2 – SN: 5d080	10/18/2020	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Daga 4 of 4
D1900V2 – SN: 5d080	10/18/2020	Page 4 of 4

Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland

PC Test

Client





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Service suisse d'étalonnage

Servizio svizzero di taratura

Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Certificate No: D1900V2-5d148_Feb19

Accreditation No.: SCS 0108

CALIBRATIONEC	ERIFICAT		
Object	D1900V2 - SN:5	d148	
Calibration procedure(s)	QA CAL-05 v11 Calibration Proc	edure for SAR Validation Source	
Calibration date:	February 21, 20	9	inits of measurements (SI). $02-26^{-23}$
This calibration certificate docume	ots the traceability to pat	ional standarda which makes the short start	m2-26/2
The measurements and the uncert	tainties with confidence r	ional standards, which realize the physical u probability are given on the following pages a	Inits of measurements (SI).
		ry facility: environment temperature (22 ± 3)	
Calibration Equipment used (M&T		,	
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr~19
Type-N mlsmatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	31-Dec-18 (No. EX3-7349 Dec18)	Dec-19
DAE4	SN: 601	04-Oct-18 (No. DAE4-601_Oct18)	Oct-19
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	07-Oct-15 (in house check Feb-19)	In house check; Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (In house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19
	Name	Function	Simeture
Calibrated by:	Manu Seltz	สพิทธิสิทธิสติสติสติสติสติสติสติสติสติสติสติสติสติ	Signature
		Laboratory Technician	ALL
Approved by:	Kalja Pokovic	Technical Manager	
			to to the
			Issued: February 21, 2019

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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Glossary:

TSL	tissue simulating liquid
IOL	U
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.9 ± 6 %	1.38 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition		
SAR measured	250 mW input power	9.65 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	39.1 W/kg ± 17.0 % (k=2)	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition		
SAR measured	250 mW input power	5.05 W/kg	

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.6 ± 6 %	1.47 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.56 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.5 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.8 Ω + 6.8 jΩ
Return Loss	- 23.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.4 Ω + 7.8 jΩ
Return Loss	- 21.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	
	1.170 ns
	1370115

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
	JEAG

DASY5 Validation Report for Head TSL

Date: 21.02.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d148

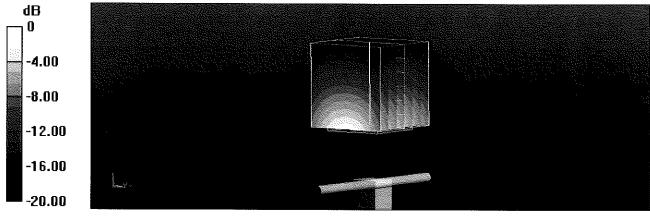
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.38$ S/m; $\varepsilon_r = 40.9$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.26, 8.26, 8.26) @ 1900 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 109.4 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 17.8 W/kg **SAR(1 g) = 9.65 W/kg; SAR(10 g) = 5.05 W/kg** Maximum value of SAR (measured) = 15.0 W/kg



0 dB = 15.0 W/kg = 11.76 dBW/kg

Impedance Measurement Plot for Head TSL

<u>File Viev</u>	v <u>C</u> hannel Sw <u>e</u> e	ep Calibration <u>T</u> r	ace <u>S</u> cale M <u>a</u> r	'ker S <u>y</u> stem <u>Wi</u> ni	dow Help	
Ch1::	Ch 1 Awg = 20 Start 1.70000 GHz				1.900000 GHz 573.82 pH 1.900000 GHz	51.822 Ω 6.8503 Ω 69.458 mU 71.260 °
10.00 5.00 -5.00 -10.00 -15.00 -20.00 -25.00 -30.00 -35.00 -40.00 Ch1: 5	Ch 1 Avg = 20 3tart 1.70000 GHz				1.900000 GHz	-23.166 dB
Status	CH 1: <u>811</u>	C*-	1-Port	Avg=20 Delay		Stop 2.10000 GHz

DASY5 Validation Report for Body TSL

Date: 21.02.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d148

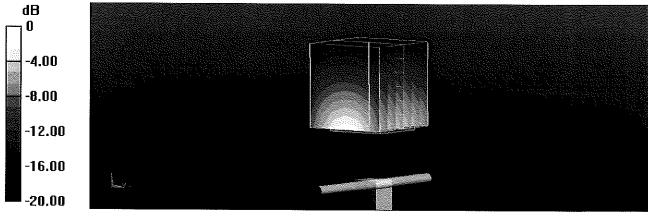
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.47$ S/m; $\epsilon_r = 53.6$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.23, 8.23, 8.23) @ 1900 MHz; Calibrated: 31.12.2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 103.7 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 17.0 W/kg SAR(1 g) = 9.56 W/kg; SAR(10 g) = 5.05 W/kg Maximum value of SAR (measured) = 14.4 W/kg



0 dB = 14.4 W/kg = 11.58 dBW/kg

Impedance Measurement Plot for Body TSL

File	View	<u>C</u> hannel	Sweep	Calibration	<u>Trace</u> <u>S</u> c.	ale M <u>a</u> rker	System	Window	Help			
		Ch1Avg=				XXX			1.900000 G 652.32 1.900000 G	pН	48.446 Ω 7.7874 Ω 80.412 mU 96.762 °	
		rt 1.70000 (-4			S	top 2,10000 GHz	
10.0	no 16	THE REAL PROPERTY OF THE PROPERTY OF THE REAL PROPE	7			Contraction of the second s		The second se	The second s			
5.0 0.0 -5.0 -10. -15. -20. -25. -30. -35. -40. (Ch 1 Awg = rt 1.70000 c	20 3Hz				>				-21.894 dB	





Certification of Calibration

Object

D1900V2 - SN: 5d148

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

2/21/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181334684
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable DAK	9/10/2019	Annual	9/10/2020	1045
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk	NC-100	Torque Wrench	5/9/2018	Biennial	5/9/2020	22217
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	9/19/2019	Annual	9/19/2020	7551
SPEAG	EX3DV4	SAR Probe	7/16/2019	Annual	7/16/2020	7410
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/17/2019	Annual	9/17/2020	1333
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/11/2019	Annual	7/11/2020	1322

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK

Object:	Date Issued:	Page 1 of 4
D1900V2 – SN: 5d148	02/21/2020	Fage 1014

DIPOLE CALIBRATION EXTENSION

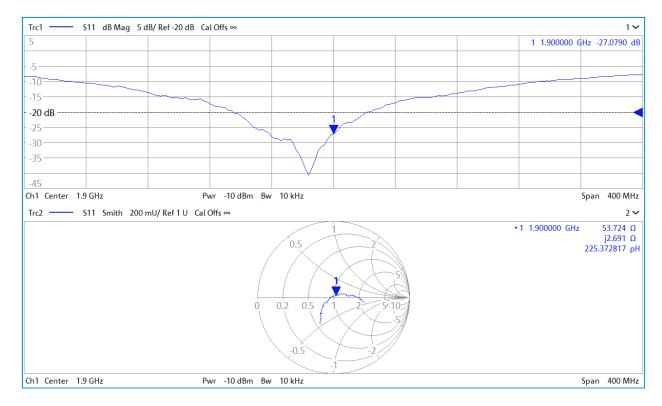
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(40-) 10/0	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2020	1.17	3.91	4.15	6.14%	2.04	2.13	4.41%	51.8	53.7	1.9	6.8	2.7	4.1	-23.2	-27.1	-16.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(40-) 1000-0	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
2/21/2019	2/21/2020	1.17	3.91	4.06	3.84%	2.05	2.08	1.46%	48.4	50.9	2.5	7.8	5.4	2.4	-21.9	-25.3	-15.60%	PASS

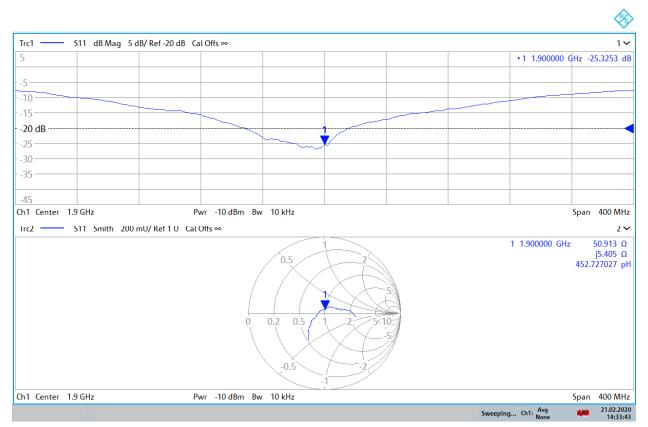
Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d148	02/21/2020	raye 2 01 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D1900V2 – SN: 5d148	02/21/2020	Page 3 of 4

Impedance & Return-Loss Measurement Plot for Body TSL



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Object:	Date Issued:	Page 4 of 4
D1900V2 – SN: 5d148	02/21/2020	Fage 4 01 4

Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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Certificate No: D1900V2-5d149_Oct18

Client PC Test

CALIBRATION C	BILLECATE		
Object	D1900V2 - SN:50	(149	
	QA CAL-05 v10 Calibration proces	dure for dipole validation kits abov	
Calibration date:	October 23, 2018		BNV 10-30-2018 BNV 10-20-2019
This calibration certificate document	ts the traceability to nation	onal standards, which realize the physical units	of measurements (SI)
		robability are given on the following pages and	BN*
All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.			
Calibration Equipment used (M&TE	crucal for calibration)		
Primary Standards	1D #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	04-Oct-18 (No. DAE4-601_Oct18)	Oct-19
O Ot d d.			
Secondary Standards	ID#	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Power sensor HP 8481A RF generator R&S SMT-06	SN: MY41092317 SN: 100972	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: U\$41080477	15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-18)	In house check: Oct-20 In house check: Oct-19
Network Analyzer Agrent LoosoA	1 314. 0 341000477	Sarwar 14 (in house theck Oct 16)	III House check. Oce 19
	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	Lelly
			Issued: October 23, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Calibration Laboratory of

Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland





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Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossarv:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole • positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. • No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power. •
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the • nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.3 ± 6 %	1.40 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.3 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
or a realized over to one (to g) of field to E	condition	
SAR measured	250 mW input power	5.11 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.9 ± 6 %	1.47 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.68 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.9 Ω + 6.3 jΩ
Return Loss	- 23.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.5 Ω + 8.2 jΩ
Return Loss	- 21.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.193 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG	
Manufactured on	March 11, 2011	

DASY5 Validation Report for Head TSL

Date: 23.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

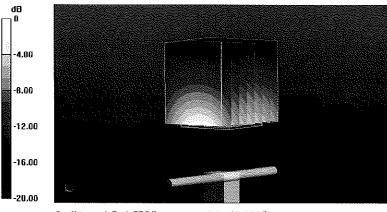
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.4$ S/m; $\epsilon_r = 40.3$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.18, 8.18, 8.18) @ 1900 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

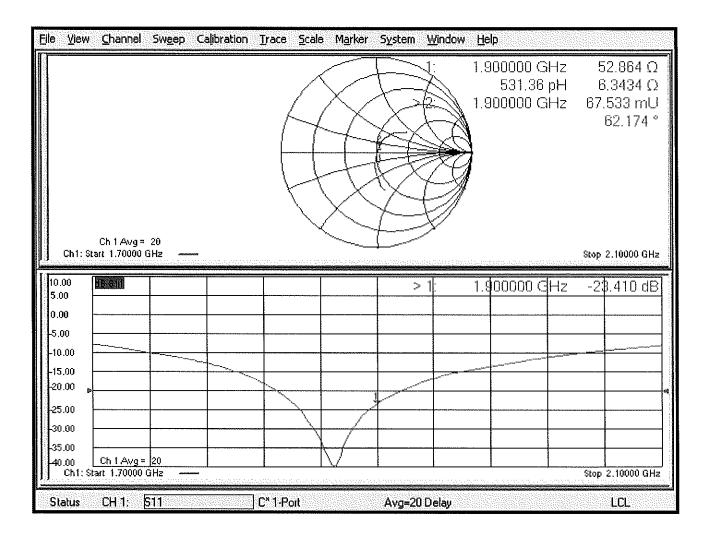
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.0 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 18.5 W/kg **SAR(1 g) = 9.8 W/kg; SAR(10 g) = 5.11 W/kg** Maximum value of SAR (measured) = 15.4 W/kg



0 dB = 15.4 W/kg = 11.88 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 23.10.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

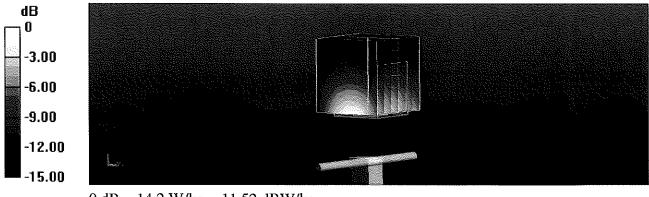
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; σ = 1.47 S/m; ϵ_r = 52.9; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15) @ 1900 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 103.1 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 17.5 W/kg SAR(1 g) = 9.68 W/kg; SAR(10 g) = 5.11 W/kg Maximum value of SAR (measured) = 14.2 W/kg



0 dB = 14.2 W/kg = 11.52 dBW/kg

Impedance Measurement Plot for Body TSL

<u>File View Channel Sweep Calibration Trace Scale Marker System Window Help</u>					
	Ch 1 Avg = 20		1: 1.90000 684 1.90000	.48 pH - 8.1713 Ω	
Ch1: 9	Start 1.70000 GHz			Stop 2.10000 GHz	
10.00 5.00 -5.00 -10.00 -15.00 -20.00 -25.00 -35.00 -40.00 Ch1: \$	Ch 1 Avg = 20 Start 1.70000 GHz		> 1: 1.90000	0 GHz -21.519 dB	
Status	CH 1: 511	C* 1-Port	Avg=20 Delay	LCL	



PCTEST ENGINEERING LABORATORY, INC. 7185 Oakland Mills Road, Columbia, MD 21046 USA

Tel. +1.410.290.6652 / Fax +1.410.290.6654 http://www.pctest.com



Certification of Calibration

Object

D1900V2 - SN:5d149

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extended Calibration date: October 18, 2019

Description: SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number	
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2021	192291470			
Control Company	4352	Ultra Long Stem Thermometer	8/2/2020	181334684			
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971	
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406	
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181	
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307	
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A	
SPEAG	DAKS-3.5	Portable Dielectric Assessment Kit	8/13/2019	Annual	8/13/2020	1041	
Anritsu	MA2411B	Pulse Power Sensor	Pulse Power Sensor 8/14/2019 Annual				
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008	
Anritsu	ML2495A	Power Meter	11/20/2018	Annual	11/20/2019	1039008	
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837	
Seekonk	NC-100	Torque Wrench	5/9/2018	Biennial	5/9/2020	22217	
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A	
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A	
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A	
SPEAG	EX3DV4	SAR Probe	2/19/2019	Annual	2/19/2020	3914	
SPEAG	EX3DV4	SAR Probe	5/16/2019	Annual	5/16/2020	7406	
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2019	Annual	5/8/2020	859	
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/14/2019	Annual	2/14/2020	1272	

Note: CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path.

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Team Lead Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK

Object:	Date Issued:	Dogo 1 of 4
D1900V2 – SN: 5d149	10/18/2019	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

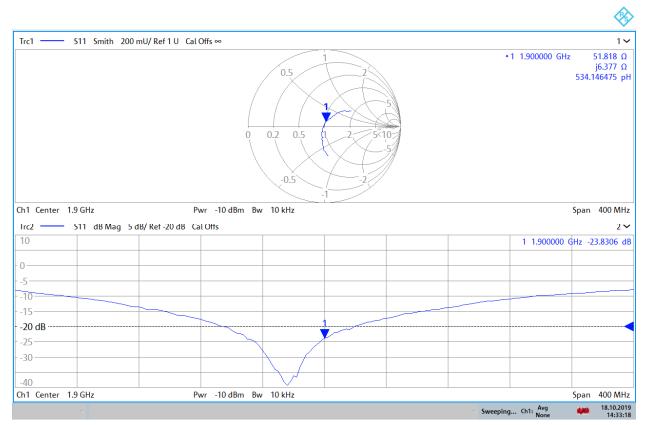
- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(96)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2019	1.193	3.93	4.24	7.89%	2.05	2.18	6.34%	52.9	51.8	1.1	6.3	6.4	0.1	-23.4	-23.8	-1.80%	Pass
		Certificate	Certificate	Measured		Certificate	Measured		Certificate	Measured		Certificate	Measured					
Calibration Date	Extension Date	Electrical Delay (ns)	SAR Target Body (1g) W/kg @ 20.0 dBm	Body SAR (1g)	(0/)	SAR Target Body (10g) W/kg @ 20.0 dBm		Deviation 10g (%)		Impedance Body (Ohm) Real	Difference (Ohm) Real	Impedance	Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL

Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d149	10/18/2019	raye 2 014

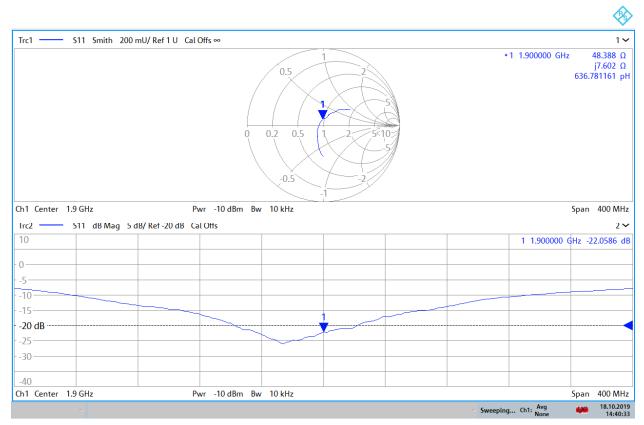
Impedance & Return-Loss Measurement Plot for Head TSL



14:33:19 18.10.2019

Object:	Date Issued:	Page 3 of 4
D1900V2 – SN: 5d149	10/18/2019	Fage 5 01 4

Impedance & Return-Loss Measurement Plot for Body TSL



14:40:34 18.10.2019

Object:	Date Issued:	Dage 4 of 4
D1900V2 – SN: 5d149	10/18/2019	Page 4 of 4





Certification of Calibration

Object

D1900V2 - SN: 5d149

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

10/18/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 1900 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	11/29/2018	Biennial	11/29/2020	181766816
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	9/29/2020	Annual	9/29/2021	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
Anritsu	MA2411B	Pulse Power Sensor	8/12/2020	Annual	8/12/2021	1207364
Anritsu	MA2411B	Pulse Power Sensor	9/22/2020	Annual	9/22/2021	1315051
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	5/13/2020	Annual	5/13/2021	MY47420603
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe				
SPEAG	EX3DV4	SAR Probe	12/11/2019	Annual	12/11/2020	7571
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/12/2020	Annual	3/12/2021	1368
SPEAG	DAE4	Data Acquisition Electronics	6/22/2020	Annual	12/7/2019	1533

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK-

Object:	Date Issued:	Page 1 of 4
D1900V2 – SN: 5d149	10/18/2020	Fage 1 014

DIPOLE CALIBRATION EXTENSION

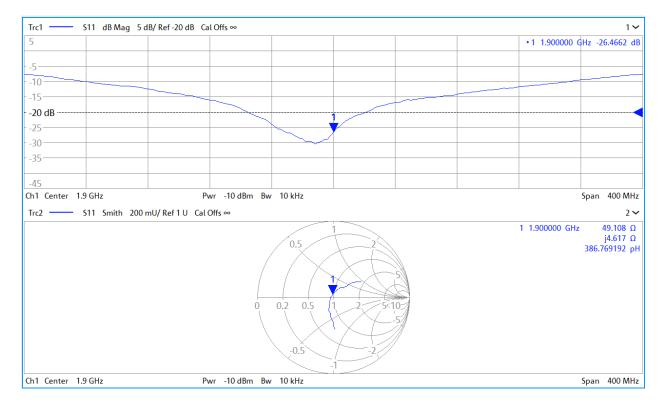
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

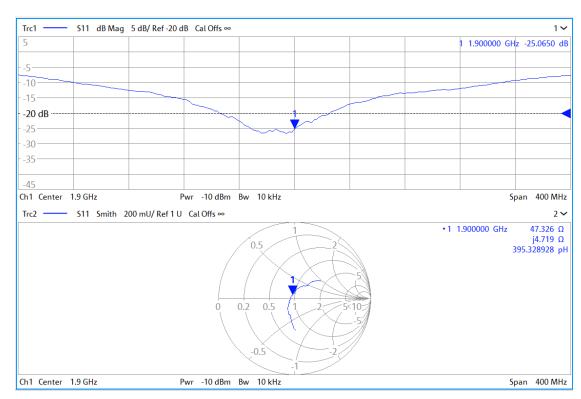
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(9/.)		(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2020	1.193	3.93	4.02	2.29%	2.05	2.05	0.00%	52.9	49.1	3.8	6.3	4.6	1.7	-23.4	-26.5	-13.10%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm		Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
10/23/2018	10/18/2020	1.193	3.94	4.07	3.30%	2.07	2.08	0.48%	48.5	47.3	1.2	8.2	4.7	3.5	-21.5	-25.1	-16.60%	PASS

Object:	Date Issued:	Page 2 of 4
D1900V2 – SN: 5d149	10/18/2020	raye 2 01 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Page 3 of 4
D1900V2 – SN: 5d149	10/18/2020	Fage 5 01 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Page 4 of 4
D1900V2 – SN: 5d149	10/18/2020	Page 4 of 4

Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





S Schweizerischer Kalibrierdienst C Service suisse d'étalonnage Servizio svizzero di taratura

S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client PC Test Certificate No: D2300V2-1073 Aug18 **IBRATION CERTIFICATE** CAI Object D2300V2 - SN:1073 Calibration procedure(s) QA CAL-05.v10 Calibration procedure for dipole validation kits above 700 MHz BNV 09-06-2018 BNV 08/10/2019 Calibration date: August 13, 2018 This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. BN 08-20-20 All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%. Calibration Equipment used (M&TE critical for calibration) Primary Standards ID # Cal Date (Certificate No.) Scheduled Calibration Power meter NRP SN: 104778 04-Apr-18 (No. 217-02672/02673) Apr-19 Power sensor NRP-Z91 SN: 103244 04-Apr-18 (No. 217-02672) Apr-19 Power sensor NRP-Z91 SN: 103245 04-Apr-18 (No. 217-02673) Apr-19 Reference 20 dB Attenuator SN: 5058 (20k) 04-Apr-18 (No. 217-02682) Apr-19 Type-N mismatch combination SN: 5047.2 / 06327 04-Apr-18 (No. 217-02683) Apr-19 Reference Probe EX3DV4 SN: 7349 30-Dec-17 (No. EX3-7349_Dec17) Dec-18 DAE4 SN: 601 26-Oct-17 (No. DAE4-601_Oct17) Oct-18 Secondary Standards ID # Check Date (in house) Scheduled Check Power meter EPM-442A SN: GB37480704 07-Oct-15 (in house check Oct-16) In house check: Oct-18 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-16) In house check: Oct-18 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-16) In house check: Oct-18 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-16) In house check: Oct-18 Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-17) In house check: Oct-18 Name Function Calibrated by: Michael Weber Laboratory Technician Approved by: Katja Pokovic Technical Manager

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D2300V2-1073_Aug18

Issued: August 13, 2018

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





S

Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage

Servizio svizzero di taratura

S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossary:

To	
TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2300 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.5	1.67 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.2 ± 6 %	1.70 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	12.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	49.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.9	1.81 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.2 ± 6 %	1.85 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	47.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.86 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.2 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.1 Ω - 5.2 jΩ
Return Loss	- 25.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.5 Ω - 4.1 jΩ
Return Loss	- 23.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.171 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	November 16, 2015

DASY5 Validation Report for Head TSL

Date: 13.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN: 1073

Communication System: UID 0 - CW; Frequency: 2300 MHz Medium parameters used: f = 2300 MHz; σ = 1.7 S/m; ϵ_r = 38.2; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.08, 8.08, 8.08) @ 2300 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 115.9 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 24.1 W/kg SAR(1 g) = 12.5 W/kg; SAR(10 g) = 6.02 W/kg Maximum value of SAR (measured) = 20.2 W/kg



Impedance Measurement Plot for Head TSL

<u>Fi</u> le	⊻iew	Channel	Sw <u>e</u> ep	Calibration	<u>T</u> race	<u>S</u> cale	M <u>a</u> rker	S <u>y</u> stem	<u>Wi</u> ndow	<u>H</u> elp				
	01.1.0	Ch 1 Awg	20								8000 G 13,259 0000 G	рF	-5 52. -1	0.050 Ω .2189 Ω 094 mU 86.467 °
	Ch1:St	art 2,10000	GHz —					- 					Stop 2	2.50000 GHz
-15 -20 -25 -30 -35	00 00 00 00 00 00 00	<u>Ch 1 Avg</u>	GHz —							2.30				2.50000 GHz
St	atus	CH 1:	511		C* 1 Po	ut	·	Avg=20	Delay					LCL

DASY5 Validation Report for Body TSL

Date: 13.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN: 1073

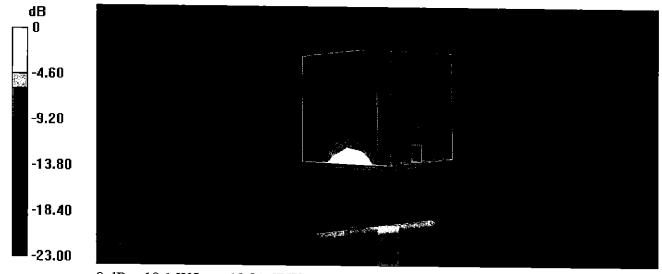
Communication System: UID 0 - CW; Frequency: 2300 MHz Medium parameters used: f = 2300 MHz; σ = 1.85 S/m; ϵ_r = 52.2; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

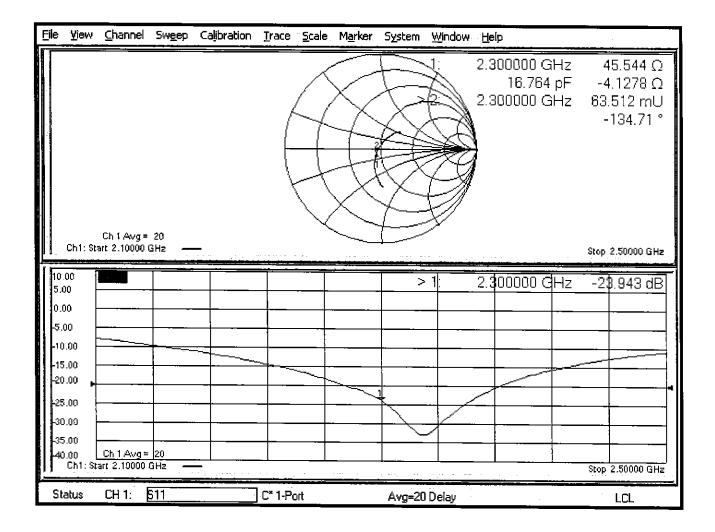
- Probe: EX3DV4 SN7349; ConvF(8.08, 8.08, 8.08) @ 2300 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 107.5 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 22.9 W/kg SAR(1 g) = 12.1 W/kg; SAR(10 g) = 5.86 W/kg Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 19.1 W/kg = 12.81 dBW/kg





PCTEST ENGINEERING LABORATORY, INC. 7185 Oakland Mills Road, Columbia, MD 21046 USA Tel. +1.410.290.6652 / Fax +1.410.290.6654

http://www.pctest.com



Certification of Calibration

Object

D2300V2 - SN: 1073

Calibration procedure(s)

Procedure for Calibration Extension for SAR Dipoles.

Calibration date:

08/09/2019

Description:

SAR Validation Dipole at 2300 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/27/2019	Annual	6/27/2020	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	EX3DV4	SAR Probe	2/19/2019	Annual	2/19/2020	7417
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/13/2019	Annual	2/13/2020	665
SPEAG	EX3DV4	SAR Probe	7/15/2019	Annual	7/15/2020	7547
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/11/2019	Annual	7/11/2020	1323
SPEAG	DAK-3.5	Dielectric Assessment Kit	9/11/2018	Annual	9/11/2019	1091

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Page 1 of 4
D2300V2 – SN: 1073	08/09/2019	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

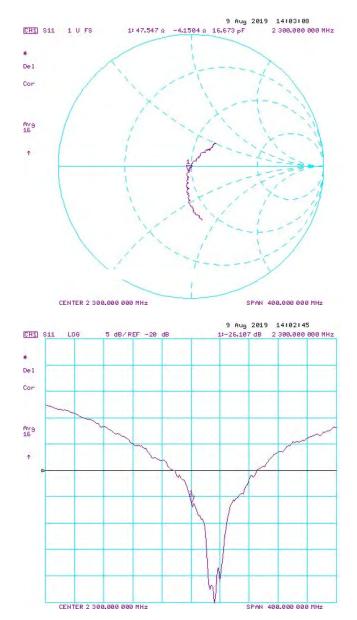
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

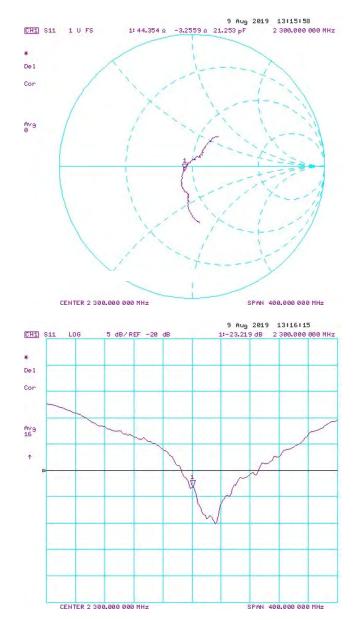
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Head SAR (1g) W/kg @ 20.0 dBm	(96)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/13/2018	8/9/2019	1.171	4.92	5.21	5.89%	2.38	2.49	4.62%	50.1	47.5	2.6	-5.2	-4.2	1	-25.7	-26.1	-1.60%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/13/2018	8/9/2019	1.171	4.77	5.05	5.87%	2.32	2.4	3.45%	45.5	44.4	1.1	-4.1	-3.3	0.8	-23.9	-23.2	2.80%	PASS

Object:	Date Issued:	Page 2 of 4
D2300V2 – SN: 1073	08/09/2019	Page 2 of 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D2300V2 – SN: 1073	08/09/2019	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Dago 4 of 4
D2300V2 – SN: 1073	08/09/2019	Page 4 of 4





Certification of Calibration

Object

D2300V2 - SN: 1073

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

8/13/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 2300 MHz

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	1/16/2020	Annual	1/16/2021	US39170118
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1207470
Anritsu	MA2411B	Pulse Power Sensor	1/21/2020	Annual	1/21/2021	1339007
Anritsu	ML2495A	Power Meter	1/15/2020	Annual	1/15/2021	1328004
Control Company	62344-734	Therm./ Clock/ Humidity Monitor	3/18/2019	Biennial	3/18/2021	192038436
Control Company	4352	Ultra Long Stem Thermometer	11/29/2018	Biennial	11/29/2020	181766816
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2208-6	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2020	Annual	5/12/2021	1070
SPEAG	EX3DV4	SAR Probe	9/19/2019	Annual	9/19/2020	7551
SPEAG	EX3DV4	SAR Probe	6/23/2020	Annual	6/23/2021	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/17/2019	Annual	9/17/2020	1333
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/18/2020	Annual	6/18/2021	1334

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Page 1 of 4
D2300V2 – SN: 1073	08/13/2020	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

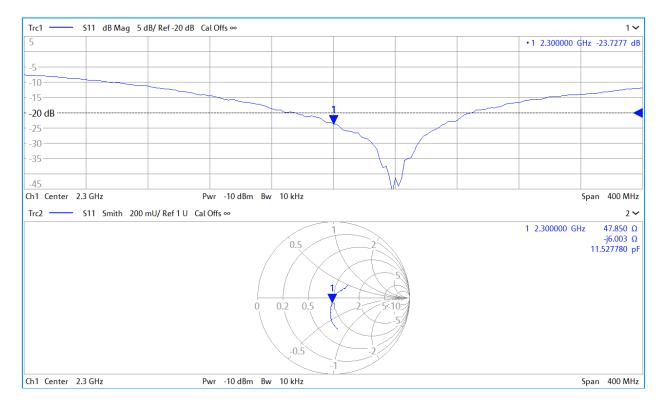
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

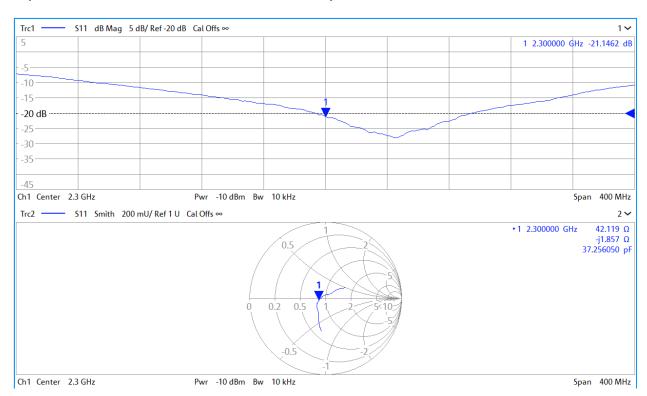
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm		Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/13/2018	8/13/2020	1.171	4.92	4.69	-4.67%	2.38	2.26	-5.04%	50.1	47.9	2.3	-5.2	-6.0	0.8	-25.7	-23.7	7.70%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm		Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/13/2018	8/13/2020	1.171	4.77	5.12	7.34%	2.32	2.43	4.74%	45.5	42.1	3.4	-4.1	-1.9	2.2	-23.9	-21.1	11.50%	PASS

Object:	Date Issued:	Dogo 2 of 4
D2300V2 – SN: 1073	08/13/2020	Page 2 of 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Dogo 2 of 4
D2300V2 – SN: 1073	08/13/2020	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Dogo 4 of 4
D2300V2 – SN: 1073	08/13/2020	Page 4 of 4

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Client PC Test

Certificate No: D2450V2-981_Aug18

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:9	81	
			
Calibration procedure(s)	QA CAL-05.v10		
	Calibration proce	edure for dipole validation kits ab	ove 700 MHz
		and the second	RNIV
	•		DIA
		- · · · · · · ·	09-26/201
Calibration date:	August 16, 2018	·	
	•	**	BN / 09-26/201 BN/ 08/10/20
		•	01.0/25
This calibration certificate docume	nts the traceability to nat	ional standards, which realize the physical ur	08/10/~~
The measurements and the uncert	ainties with confidence r	probability are given on the following pages a	nits of measurements (SI).
		sobability are given on the following pages at	nd are part of the certificate. BN 08-20-20
All calibrations have been conduct	od in the stars of the sec	e	
sal canonadoris nave been conduct	ed in the closed laborato	ry facility: environment temperature (22 \pm 3)°	°C and humidity < 70%.
Calibration Equipment used (M&TI	= critical for calibration)		
Deleners Observice	l		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18
Secondary Standards	ID #	Oberla Deta (in b	
Power meter EPM-442A	SN: GB37480704	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	1	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: MY41092317 SN: 100972	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer Agilent E8358A		15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Hotront Analyzer Agnenic E6356A	SN: US41080477	31-Mar-14 (in house check Oct-17)	In house check: Oct-18
	Name	Function	Signatura
Calibrated by:	Leif Klysner	Laboratory Technician	Signature
-			Sel Tille
			The former of the second secon
Approved by:	Katja Pokovic	Technical Manager	MA
	,	· · ·	All as-
			Issued: August 23, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





Schweizerischer Kalibrierdienst

S Service suisse d'étalonnage С

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S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossarv:

TSL ConvF N/A	tissue simulating liquid sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5.0 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.7 ± 6 %	1.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.4 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.8 ± 6 %	2.02 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.9 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.11 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.2 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.0 Ω + 2.3 jΩ
Return Loss	- 25.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.2 Ω + 4.7 jΩ
Return Loss	- 26.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.162 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG	
Manufactured on	December 30, 2014	

Appendix (Additional assessments outside the scope of SCS 0108)

Measurement Conditions

DASY system configuration, as far as not given on page 1 and 3.

Phantom		
Filantom	SAM Head Phantom	For usage with cSAR3DV2-R/L
		TO USAGE WILL COARSDYZ-R/L

SAR result with SAM Head (Top)

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	54.0 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.2 W/kg ± 16.9 % (k=2)

SAR result with SAM Head (Mouth)

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	54.0 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.3 W/kg ± 16.9 % (k=2)

SAR result with SAM Head (Neck)

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.2 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.4 W/kg ± 16.9 % (k=2)

SAR result with SAM Head (Ear)

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	8.74 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	34.7 W/kg ± 17.5 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	17.5 W/kg ± 16.9 % (k=2)

DASY5 Validation Report for Head TSL

Date: 13.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:981

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; σ = 1.86 S/m; ϵ_r = 37.7; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

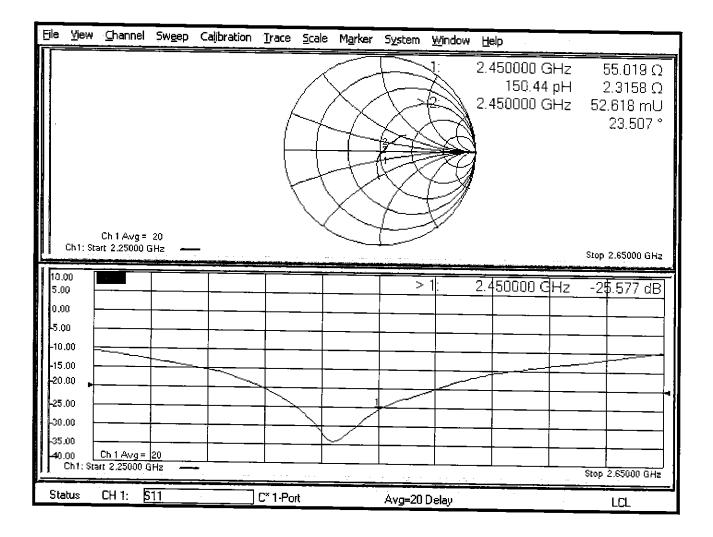
- Probe: EX3DV4 SN7349; ConvF(7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 116.6 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 26.7 W/kg SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.2 W/kg Maximum value of SAR (measured) = 22.1 W/kg



0 dB = 22.1 W/kg = 13.44 dBW/kg



DASY5 Validation Report for Body TSL

Date: 13.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:981

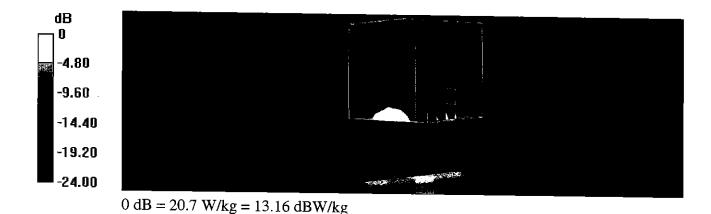
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; σ = 2.02 S/m; ϵ_r = 51.8; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

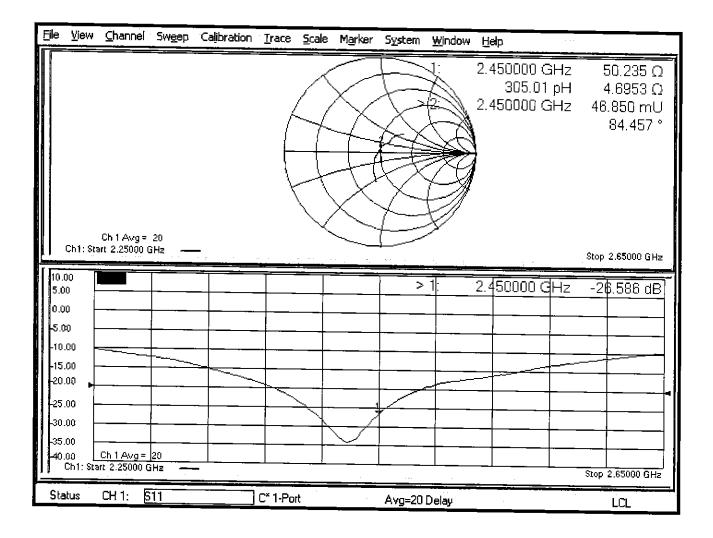
- Probe: EX3DV4 SN7349; ConvF(8.01, 8.01, 8.01) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 107.0 V/m; Power Drift = -0.08 dB Peak SAR (extrapolated) = 25.3 W/kg SAR(1 g) = 13 W/kg; SAR(10 g) = 6.11 W/kg Maximum value of SAR (measured) = 20.7 W/kg



Impedance Measurement Plot for Body TSL



Date: 16.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:981

Communication System: UID 0 - CW ; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; $\sigma = 1.85$ S/m; $\epsilon_r = 40.2$; $\rho = 1000$ kg/m³ Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

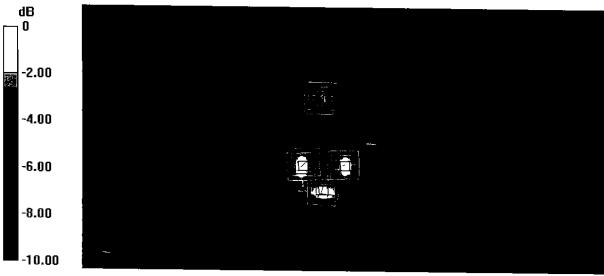
- Probe: EX3DV4 SN7349; ConvF(7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: SAM Head
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

SAM Head Top/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 116.2 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 26.4 W/kg SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.33 W/kg Maximum value of SAR (measured) = 22.0 W/kg

SAM Head Mouth/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 116.9 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 26.3 W/kg SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.35 W/kg Maximum value of SAR (measured) = 21.7 W/kg

SAM Head Neck/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 112.0 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 24.1 W/kg SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.11 W/kg Maximum value of SAR (measured) = 20.5 W/kg

SAM Head Ear/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 91.03 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 15.8 W/kg SAR(1 g) = 8.74 W/kg; SAR(10 g) = 4.4 W/kg Maximum value of SAR (measured) = 13.5 W/kg



0 dB = 22.0 W/kg = 13.42 dBW/kg



PCTEST ENGINEERING LABORATORY, INC. 7185 Oakland Mills Road, Columbia, MD 21046 USA Tel. +1.410.290.6652 / Fax +1.410.290.6654

http://www.pctest.com



Certification of Calibration

Object

D2450V2 - SN: 981

08/09/2019

Calibration procedure(s)

Procedure for Calibration Extension for SAR Dipoles.

Calibration date:

Description:

SAR Validation Dipole at 2450 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	10/2/2018	Annual	10/2/2019	US39170118
Agilent	N5182A	MXG Vector Signal Generator	6/27/2019	Annual	6/27/2020	US46240505
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1207470
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1339007
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Control Company	4352	Ultra Long Stem Thermometer	2/28/2018	Biennial	2/28/2020	170330160
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Pasternack	NC-100	Torque Wrench	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	EX3DV4	SAR Probe	2/19/2019	Annual	2/19/2020	7417
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/13/2019	Annual	2/13/2020	665
SPEAG	EX3DV4	SAR Probe	7/15/2019	Annual	7/15/2020	7547
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/11/2019	Annual	7/11/2020	1323
SPEAG	DAK-3.5	Dielectric Assessment Kit	9/11/2018	Annual	9/11/2019	1091

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Page 1 of 4	
D2450V2 – SN: 981	08/09/2019	Page 1 of 4	

DIPOLE CALIBRATION EXTENSION

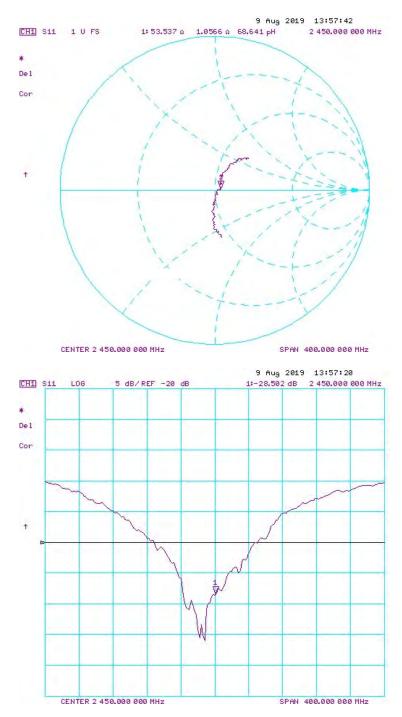
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

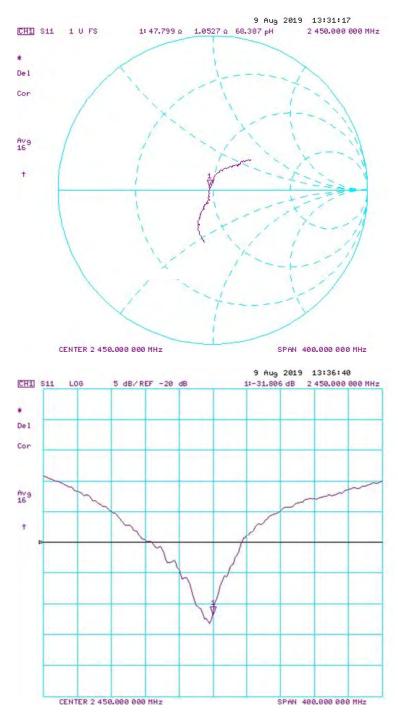
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Head (1g) W/kg @ 20.0 dBm	ubiii	(%)	dBm	(10g) W/kg @ 20.0 dBm		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
8/16/2018	8/9/2019	1.162	5.23	5.53	5.74%	2.44	2.56	4.92%	55	53.5	1.5	2.3	1.1	1.2	-25.6	-28.5	-11.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/16/2018	8/9/2019	1.162	5.09	4.98	-2.16%	2.42	2.28	-5.79%	50.2	47.8	2.4	4.7	1.1	3.6	-26.6	-31.8	-19.60%	PASS

Object:	Date Issued:	Page 2 of 4
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Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D2450V2 – SN: 981	08/09/2019	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Daga 4 of 4
D2450V2 – SN: 981	08/09/2019	Page 4 of 4





Certification of Calibration

Object

D2450V2 - SN: 981

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

8/16/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 2450 MHz

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	11/29/2018	Biennial	11/29/2020	181766816
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Agilent	85033E	3.5mm Standard Calibration Kit	6/6/2020	Annual	6/6/2021	MY53402352
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable DAK	9/10/2019	Annual	9/10/2020	1045
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/27/2019	Annual	8/27/2020	1339027
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk Inc	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	1/21/2020	Annual	1/21/2021	3589
SPEAG	EX3DV4	SAR Probe	6/23/2020	Annual	6/23/2021	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/18/2020	Annual	6/18/2021	1334
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/23/2020	Annual	1/13/2021	1558

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK

Object:	Date Issued:	Page 1 of 4
D2450V2 – SN: 981	08/16/2020	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

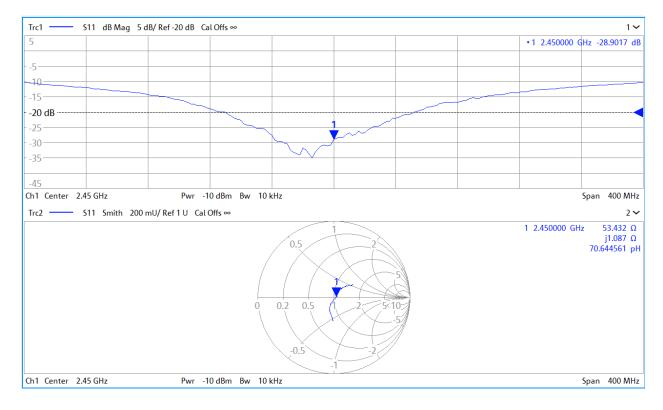
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

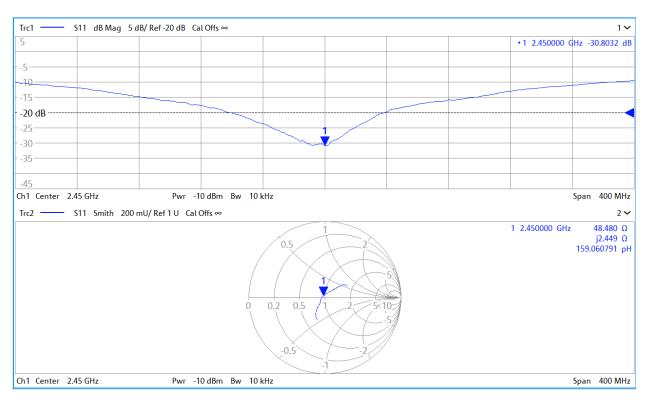
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Head (1g) W/kg @ 20.0 dBm	ubiii	(%)	dBm	(10a) W/ka @		Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Head (dB)	Deviation (%)	
8/16/2018	8/16/2020	1.162	5.23	5.31	1.53%	2.44	2.4	-1.64%	55	53.4	1.6	2.3	1.1	1.2	-25.6	-28.9	-12.90%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/16/2018	8/16/2020	1.162	5.09	5.3	4.13%	2.42	2.43	0.41%	50.2	48.5	1.7	4.7	2.4	2.3	-26.6	-30.8	-15.80%	PASS

Object:	Date Issued:	Dogo 2 of 4
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Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Dogo 2 of 4
D2450V2 – SN: 981	08/16/2020	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Dogo 4 of 4
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Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





S Schweizerischer Kalibrierdienst

Service suïsse d'étalonnage

Servizio svizzero di taratura S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Client PC Test		C	ertificate'No: D2600V2=1004_Apr18	
OANE BERAVE ON RE	EDHEIGAHE			
Object	D2600V2-SN/10	04		
Calibration procedure(s)	QA GALEOS VID			
	Calibration proce	dure for dipole validatio		18 - Honde
Calibration date:	April 11, 2018		oh- BU	18 Extende 20-2019 108 12020 Extend
This calibration certificate docume The measurements and the uncer	nts the traceability to nati tainlies with confidence p	lonal standards, which realize th robability are given on the follow	e physical units of measurements (SI). ving pages and are part of the certificate.	
			ure (22 \pm 3)°C and humidity < 70%.	128 Extend
Calibration Equipment used (M&T	E critical for calibration)			
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/0	2673) Apr-19	
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19	
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19	
Reference 20 dB Attenuator	SN: 5058 (20K)	04-Apr-18 (No. 217-02682)	Apr-19	
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19	
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349[lec17) Dec-18	
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_0	Oct-18	
Secondary Standards	ID #	Check Date (in house)	Scheduled Check	
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check (Oct-16) in house check: Oct-18	
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check (Oct-16) In house check: Oct-18	
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check (Dct-16) In house check: Oct-18	
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check (Det-16) In house check: Oct-18	
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check (Oct-17) In house check: Oct-18	
	Name	Function	Signature	
Callbrated by:	Michael Weber	Laboratory Tec	nician Aless	
Approved by:	Katla Rokovic	Technical Man	gen status	
This calibration certificate shall n	ot be reproduced except	in full without written approval o	issued: April 12, 2018 the laboratory.	
		•		

Certificate No: D2600V2-1004_Apr18

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





S

Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
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- S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity	
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m	
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.8 ± 6 %	2.03 mho/m ± 6 %	
Head TSL temperature change during test	< 0.5 °C			

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	55.9 W/kg ± 17.0 % (k=2)
	F	······································
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.1 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity	
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m	
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.1 ± 6 % 2.19 mho/m ± 6		
Body TSL temperature change during test	< 0.5 °C		,	

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	54.8 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.20 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.7 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.7 Ω - 5.7 jΩ
Return Loss	- 24.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.0 Ω - 3.8 jΩ
Return Loss	- 24.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	A I I I I I I I I I I
	1.149 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	December 23, 2006

DASY5 Validation Report for Head TSL

Date: 11.04.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1004

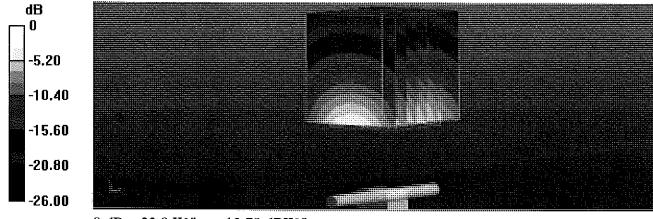
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 37.8$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

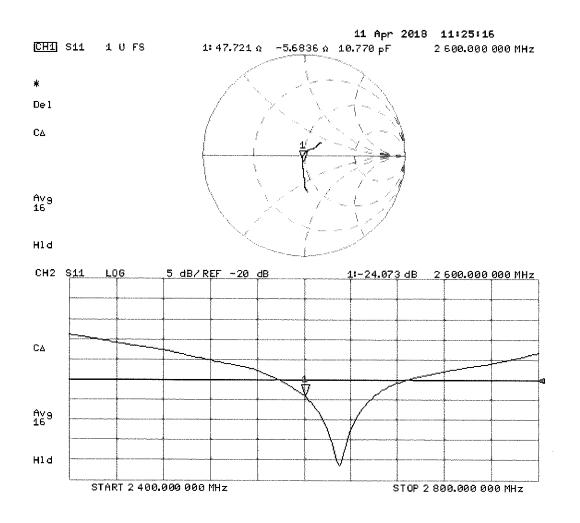
- Probe: EX3DV4 SN7349; ConvF(7.7, 7.7, 7.7); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 118.5 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 28.6 W/kg SAR(1 g) = 14.3 W/kg; SAR(10 g) = 6.35 W/kg Maximum value of SAR (measured) = 23.9 W/kg



0 dB = 23.9 W/kg = 13.78 dBW/kg



DASY5 Validation Report for Body TSL

Date: 11.04.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1004

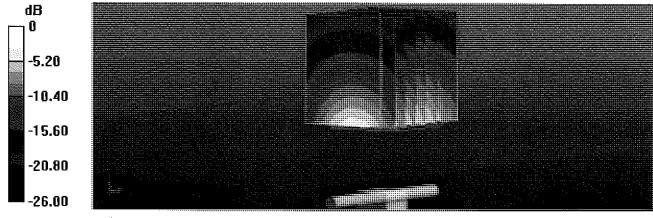
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; σ = 2.19 S/m; ϵ_r = 52.1; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

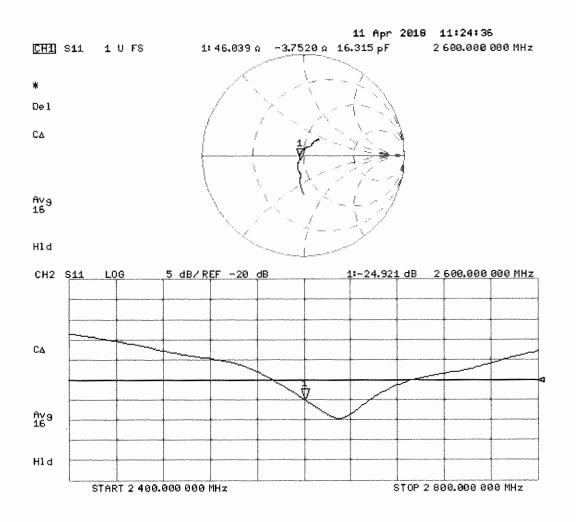
- Probe: EX3DV4 SN7349; ConvF(7.81, 7.81, 7.81); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 108.5 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 28.3 W/kg SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.2 W/kg Maximum value of SAR (measured) = 22.9 W/kg



0 dB = 22.9 W/kg = 13.60 dBW/kg





PCTEST ENGINEERING LABORATORY, INC. 7185 Oakland Mills Road, Columbia, MD 21046 USA Tel. +1.410.290.6652 / Fax +1.410.290.6654

http://www.pctest.com



Certification of Calibration

Object

D2600V2 - SN: 1004

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 4/11/2019

Description:

SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	8753ES	S-Parameter Network Analyzer	3/11/2019	Annual	3/11/2020	US39170122
Agilent	N5182A	MXG Vector Signal Generator	4/18/2018	Annual	4/18/2019	MY47420800
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Anritsu	MA2411B	Pulse Power Sensor	11/20/2018	Annual	11/20/2019	1027293
Anritsu	MA2411B	Pulse Power Sensor	10/30/2018	Annual	10/30/2019	1126066
Anritsu	ML2495A	Power Meter	10/21/2018	Annual	10/21/2019	941001
Control Company	4040	Therm./ Clock/ Humidity Monitor	10/9/2018	Biennial	10/9/2020	181647811
Control Company	4352	Ultra Long Stem Thermometer	5/2/2017	Biennial	5/2/2019	170330156
Keysight	772D	Dual Directional Coupler	CBT	N/A	CBT	MY52180215
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/4/2018	Annual	6/4/2019	MY53401181
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE2209-10	Bidirectional Coupler	CBT	N/A	CBT	N/A
Seekonk	NC-100	Torque Wrench	7/11/2018	Annual	7/11/2019	N/A
SPEAG	EX3DV4	SAR Probe	6/25/2018	Annual	6/25/2019	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/18/2018	Annual	6/18/2019	1334
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/13/2019	Annual	2/13/2020	665
SPEAG	EX3DV4	SAR Probe	2/19/2019	Annual	2/19/2020	7417
SPEAG	DAK-3.5	Dielectric Assessment Kit	9/11/2018	Annual	9/11/2019	1091

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	XOK-

Object:	Date Issued:	Page 1 of 4
D2600V2 – SN: 1004	04/11/2019	Fage 1014

DIPOLE CALIBRATION EXTENSION

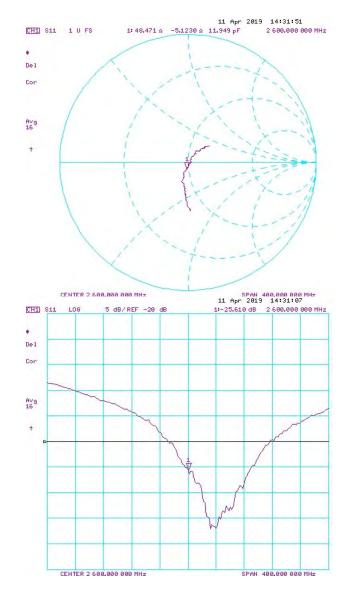
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

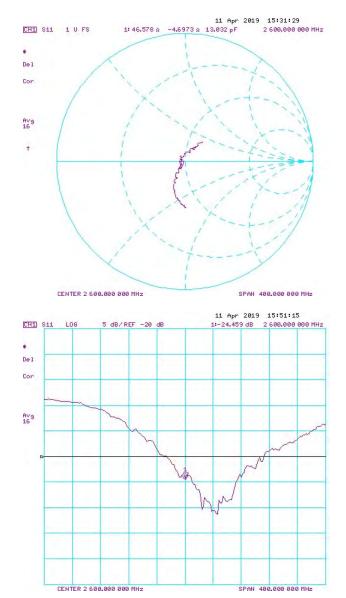
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
4/11/2018	4/11/2019	1.149	5.59	5.51	-1.43%	2.51	2.47	-1.59%	47.7	48.5	0.8	-5.7	-5.1	0.6	-24.1	-25.6	-6.30%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
4/11/2018	4/11/2019	1.149	5.48	5.65	3.10%	2.47	2.48	0.40%	46	46.6	0.6	-3.8	-4.7	0.9	-24.9	-24.5	1.80%	PASS

Object:	Date Issued:	Dogo 2 of 4
D2600V2 – SN: 1004	04/11/2019	Page 2 of 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Page 3 of 4
D2600V2 – SN: 1004	04/11/2019	Page 5 01 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Dogo 4 of 4
D2600V2 – SN: 1004	04/11/2019	Page 4 of 4





Certification of Calibration

Object

D2600V2 - SN: 1004

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

4/11/2020

Extension Calibration date:

Description:

SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181334684
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable DAK	9/10/2019	Annual	9/10/2020	1045
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk	NC-100	Torque Wrench (8" lb)	5/23/2018	Biennial	5/23/2020	22217
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	1/21/2020	Annual	1/21/2021	3589
SPEAG	EX3DV4	SAR Probe	9/19/2019	Annual	9/19/2020	7552
SPEAG	DAE4	Dasy Data Acquisition Electronics	9/12/2019	Annual	9/12/2020	1449
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/13/2020	Annual	1/13/2021	1558

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halbfoster	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	ROK

Object:	Date Issued:	Page 1 of 4
D2600V2 – SN: 1004	04/11/2020	Fage 1014

DIPOLE CALIBRATION EXTENSION

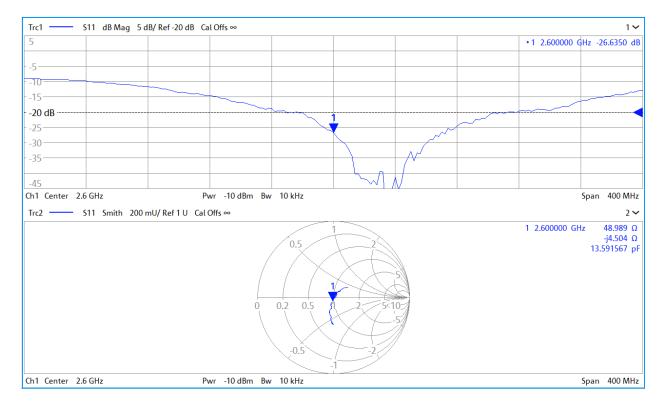
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

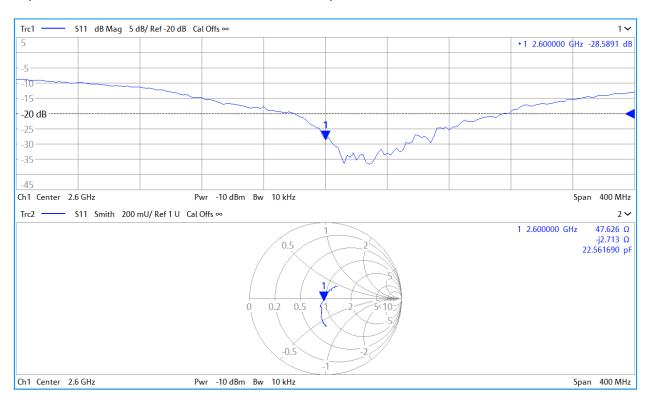
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(40-) 10/0-0	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
4/11/2018	4/11/2020	1.419	5.59	5.78	3.40%	2.51	2.59	3.19%	47.7	49.0	1.3	-5.7	-4.5	1.2	-24.1	-26.6	-10.50%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	(0/)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	(10-) (10-	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
4/11/2018	4/11/2020	1.149	5.48	5.16	-5.84%	2.47	2.36	-4.45%	46	47.6	1.6	-3.8	-2.7	1.1	-24.9	-28.6	-14.80%	PASS

Object:	Date Issued:	Dogo 2 of 4
D2600V2 – SN: 1004	04/11/2020	Page 2 of 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4
D2600V2 – SN: 1004	04/11/2020	Page 3 of 4



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Dogo 4 of 4
D2600V2 – SN: 1004	04/11/2020	Page 4 of 4

Calibration Laboratory of

PC Test

Client

Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer Kalibrierdienst S

- Service suisse d'étalonnage C
 - Servizio svizzero di taratura
- S **Swiss Calibration Service**

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Certificate No: D2600V2-1064_Jun19

CALIBRATION CERTIFICATE

Object	D2600V2 - SN:10	164	
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			ANV
Calibration procedure(s)	QA CAL-05.v11		BNV BNV 181/2019
candiation procedure(s)			
	Calibration Proce	dure for SAR Validation Sources	between 0.7-3 GHz
			RN
			··· 06-70-30
Calibration date:	June 14, 2019		
	·····		
This calibration partificate documer	to the tracebility to not	and standards, which realize the physical up	ite of monourements (CI)
		onal standards, which realize the physical ur	
The measurements and the uncertain	anties with confidence p	robability are given on the following pages ar	id are part of the certificate.
l			
All calibrations have been conducte	ed in the closed laborato	ry facility: environment temperature (22 \pm 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02893)	Apr-20
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	May-20
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20
		00 Apr 10 (No. DAL+001_Apr 0)	Αμ-20
Secondary Standards	D#	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Feb-19)	In house check: Oct-20
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)	In house check: Oct-20
RF generator R&S SMT-06			In house check: Oct-20
0	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19
	•	–	
	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	
			Miller
Approved by:	Katja Pokovic	Technical Manager	Clint
			/tent
			Issued: June 20, 2019
This calibration certificate shall not	be reproduced except in	full without written approval of the laboratory	,
			•

Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





S

Schweizerischer Kalibrierdienst

- Service suisse d'étalonnage С
- Servizio svizzero di taratura S

Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossarv:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end • of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power.
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.3 ± 6 %	2.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	58.1 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.59 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	26.0 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.5 ± 6 %	2.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	14.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	55.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.33 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.0 W/kg ± 16.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.8 Ω - 6.9 jΩ
Return Loss	- 23.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.6 Ω - 4.4 jΩ
Return Loss	- 24.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.151 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1064

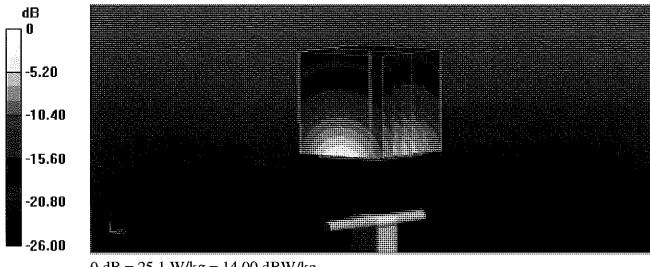
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; σ = 2.03 S/m; ϵ_r = 37.3; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.69, 7.69, 7.69) @ 2600 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 120.9 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 30.2 W/kg **SAR(1 g) = 14.9 W/kg; SAR(10 g) = 6.59 W/kg** Maximum value of SAR (measured) = 25.1 W/kg



Impedance Measurement Plot for Head TSL

File View	<u>C</u> hannel Sw <u>e</u> ep	o Ca <u>l</u> ibration <u>T</u>	race <u>S</u> cale I	M <u>a</u> rker S <u>y</u> stem	<u>Window H</u> elp		
			X		A)0000 GHz 8.8630 pF)0000 GHz	49.847 Ω -6.9066 Ω 69.025 mU -87.316 °
Chi:S	Ch 1 Avg = 20 Start 2.40000 GHz						Stop 2.80000 GHz
10.00 5.00 -5.00 -10.00 -15.00 -20.00 -25.00 -35.00 -35.00 -40.00 -Ch1: S	Ch 1 Avg = 20 Start 2,40000 GHz =						-23.220 dB
Status	CH 1: 511	C	1-Port	Avg=20 [)elay		LCL

DASY5 Validation Report for Body TSL

Date: 14.06.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1064

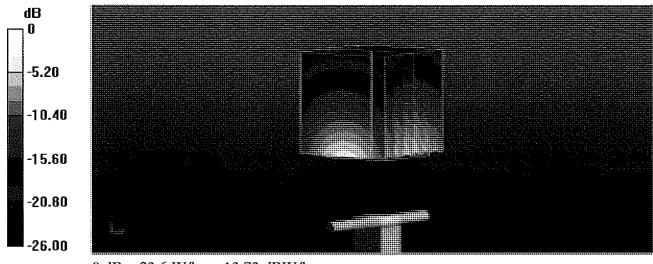
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2.22$ S/m; $\varepsilon_r = 50.5$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.8, 7.8, 7.8) @ 2600 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 110.6 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.33 W/kg Maximum value of SAR (measured) = 23.6 W/kg



0 dB = 23.6 W/kg = 13.73 dBW/kg

Impedance Measurement Plot for Body TSL

File	View	<u>C</u> hannel	Sw <u>e</u> ep	Calibration	<u>Trace</u> <u>S</u> cale	e M <u>a</u> rker	System Win	dow <u>H</u> e)p		
		Ch 1 Avg =	20		A	XXX		X	300000 GHz 14.009 pF 300000 GHz	-4.3i 56.94	345 Ω 396 Ω 4 mU 4.93 °
	Ch1: St	art 2.40000					1			Stop 2.8)000 GHz
10. 5.0		HE SAM					> 1;	2.0	00000 GHz	-24.8	91 dB
-5.(-10 -15 -20 -25 -30 -35 -40	00 .00 .00 .00 .00	<u>Ch 1 Avg =</u> art 2.40000	20 3Hz								





Certification of Calibration

Object

D2600V2 - SN: 1064

Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.

June 14, 2020

Extended Calibration date:

Description:

SAR Validation Dipole at 2600 MHz.

Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./Clock/Humidity Monitor	6/29/2019	Biennial	6/29/2021	192291470
Control Company	4352	Ultra Long Stem Thermometer	8/2/2018	Biennial	8/2/2020	181334684
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	7/2/2019	Annual	7/2/2020	MY53401181
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/11/2019	Annual	10/11/2020	101307
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
SPEAG	DAKS-3.5	Portable DAK	9/10/2019	Annual	9/10/2020	1045
Anritsu	MA2411B	Pulse Power Sensor	8/14/2019	Annual	8/14/2020	1315051
Anritsu	MA2411B	Pulse Power Sensor	8/8/2019	Annual	8/8/2020	1339008
Anritsu	ML2495A	Power Meter	12/17/2019	Annual	12/17/2020	941001
Agilent	N5182A	MXG Vector Signal Generator	8/19/2019	Annual	8/19/2020	MY47420837
Seekonk	NC-100	Torque Wrench	7/18/2019	Annual	7/18/2020	N/A
MiniCircuits	ZHDC-16-63-S+	Bidirectional Coupler	CBT	N/A	CBT	N/A
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
SPEAG	EX3DV4	SAR Probe	1/21/2020	Annual	1/21/2021	3589
SPEAG	EX3DV4	SAR Probe	7/15/2019	Annual	7/15/2020	7547
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/11/2019	Annual	7/11/2020	1323
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/13/2020	Annual	1/13/2021	1558

Measurement Uncertainty = $\pm 23\%$ (k=2)

	Name	Function	Signature
Calibrated By:	Test Engineer	Test Engineer	BRODIE HALBFOSTER
Approved By:	Kaitlin O'Keefe	Managing Director	ROK

Object:	Date Issued:	Page 1 of 4
D2600V2 – SN: 1064	6/14/2020	Page 1 of 4

DIPOLE CALIBRATION EXTENSION

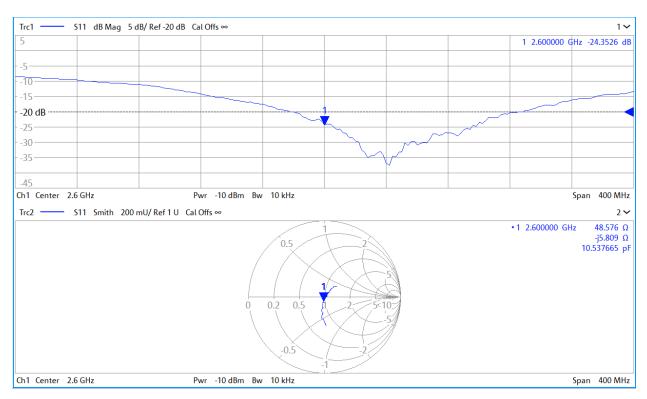
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

- 1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
- 2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
- 3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

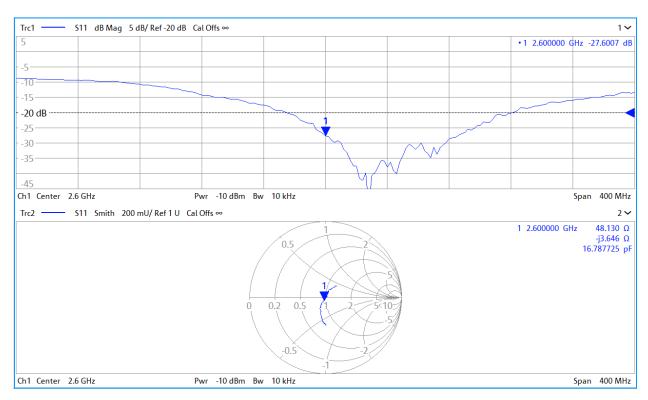
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Head SAR (1g) W/kg @ 20.0 dBm		Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	(40-) 10/0	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2020	1.151	5.81	5.68	-2.24%	2.6	2.56	-1.54%	49.8	48.6	1.2	-6.9	-5.8	1.1	-23.2	-24.4	-5.00%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)		Measured Body SAR (1g) W/kg @ 20.0 dBm			(10a) W/ka @	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
6/14/2019	6/14/2020	1.151	5.56	5.43	-2.34%	2.5	2.39	-4.40%	46.6	48.1	1.5	-4.4	-3.6	0.8	-24.9	-27.6	-10.80%	PASS

Object:	Date Issued:	Dogo 2 of 4
D2600V2 – SN: 1064	6/14/2020	Page 2 of 4



Impedance & Return-Loss Measurement Plot for Head TSL

Object:	Date Issued:	Daga 2 of 4	
D2600V2 – SN: 1064	6/14/2020	Page 3 of 4	



Impedance & Return-Loss Measurement Plot for Body TSL

Object:	Date Issued:	Page 4 of 4	
D2600V2 – SN: 1064	6/14/2020	Page 4 of 4	

Calibration Laboratory of

PC Test

Client

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland

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Certificate No: D3500V2-1097_Jan20

CALIBRATION CERTIFICATE D3500V2 - SN:1097 Object Calibration procedure(s) **QA CAL-22.v4** Calibration Procedure for SAR Validation Sources between 3-6 GHz 13N' 2020 January 21, 2020 Calibration date: This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%. Calibration Equipment used (M&TE critical for calibration) Scheduled Calibration ID # Cal Date (Certificate No.) Primary Standards SN: 104778 03-Apr-19 (No. 217-02892/02893) Apr-20 Power meter NRP Apr-20 Power sensor NRP-Z91 SN: 103244 03-Apr-19 (No. 217-02892) Power sensor NRP-Z91 SN: 103245 03-Apr-19 (No. 217-02893) Apr-20 Apr-20 Reference 20 dB Attenuator SN: 5058 (20k) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) Apr-20 Type-N mismatch combination SN: 5047.2 / 06327 Dec-20 SN: 3503 31-Dec-19 (No. EX3-3503_Dec19) Reference Probe EX3DV4 Dec-20 SN: 601 27-Dec-19 (No. DAE4-601_Dec19) DAE4 Scheduled Check Secondary Standards ID # Check Date (in house) In house check: Oct-20 SN: GB39512475 30-Oct-14 (in house check Feb-19) Power meter E4419B In house check: Oct-20 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) SN: MY41092317 07-Oct-15 (in house check Oct-18) in house check: Oct-20 Power sensor HP 8481A In house check: Oct-20 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-20 SN: US41080477 31-Mar-14 (in house check Oct-19) Network Analyzer Agilent E8358A Function Signature Name Jeton Kastrati Laboratory Technician Calibrated by: Katja Pokovic Technical Manager Approved by: Issued: January 23, 2020 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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Accreditation No.: SCS 0108

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Glossarv:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole 0 positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. ۲ No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power. 0
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna ø connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the • nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.3
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3500 MHz ± 1 MHz	

Head TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.9	2.91 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.0 ± 6 %	2.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.67 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	66.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.50 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.9 W/kg ± 19.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	51.3	3.31 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.8 ± 6 %	3.33 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	6.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	64.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.40 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.8 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.4 Ω + 3.0 jΩ
Return Loss	-30.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.8 Ω + 4.1 jΩ
Return Loss	- 27.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.133 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

DASY5 Validation Report for Head TSL

Date: 21.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

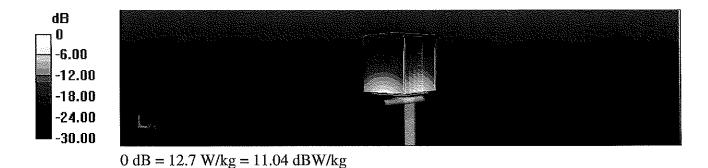
DUT: Dipole 3500 MHz; Type: D3500V2; Serial: D3500V2 - SN:1097

Communication System: UID 0 - CW; Frequency: 3500 MHz Medium parameters used: f = 3500 MHz; $\sigma = 2.9$ S/m; $\epsilon_r = 37$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

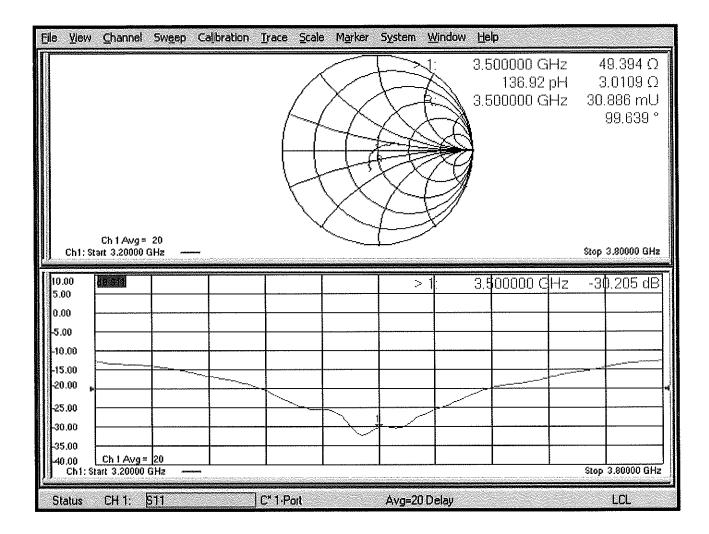
DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.91, 7.91, 7.91) @ 3500 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3500MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 70.89 V/m; Power Drift = 0.06 dB Peak SAR (extrapolated) = 18.3 W/kg SAR(1 g) = 6.67 W/kg; SAR(10 g) = 2.5 W/kg Smallest distance from peaks to all points 3 dB below = 8.4 mm Ratio of SAR at M2 to SAR at M1 = 74.1% Maximum value of SAR (measured) = 12.7 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 21.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

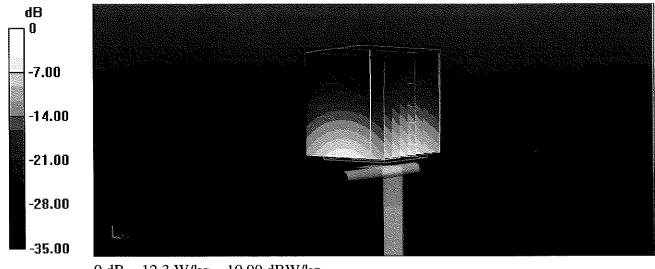
DUT: Dipole 3500 MHz; Type: D3500V2; Serial: D3500V2 - SN:1097

Communication System: UID 0 - CW; Frequency: 3500 MHz Medium parameters used: f = 3500 MHz; σ = 3.33 S/m; ϵ_r = 49.8; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.46, 7.46, 7.46) @ 3500 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm, f=3500MHz/Zoom Scan , dist=1.4mm (8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 65.34 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 17.5 W/kg SAR(1 g) = 6.47 W/kg; SAR(10 g) = 2.4 W/kg Smallest distance from peaks to all points 3 dB below = 8 mm Ratio of SAR at M2 to SAR at M1 = 75.1% Maximum value of SAR (measured) = 12.3 W/kg



0 dB = 12.3 W/kg = 10.90 dBW/kg

Impedance Measurement Plot for Body TSL

<u>File View C</u> hannel	Sweep Calibration	<u>Trace Scale Marker</u>	System <u>W</u> indow	Help	
Ch 1 Avg =	: 20			3.500000 GHz 184.63 pH 3.500000 GHz	48.767 Ω 4.0601 Ω 42.925 mU 104.54 °
Ch1: Start 3.30000	GHz				Stop 3.70000 GHz
10.00 5.00 5.00 5.00 5.00 5.00 -10.00 -15.00 -25.00 -25.00 -25.00 -30.00 -35.00 -40.00 Ch 1 Avg =	20			3.\$00000 GHz	-27.348 dB
Ch1: Start 3.30000	GHz				Stop 3.70000 GHz

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Accreditation No.: SCS 0108

Client PC Test	Maria da Subara Calendaria Nona da Contrata da Contrat	c c	Certificate No: D3700V2-1067_Jan20	
CALIBRATION CI	ERTIFICATE			
Object	D3700V2 - SN:1	067		
Calibration procedure(s)	QA CAL-22.v4 Calibration Proce	edure for SAR Validatio	n Sources between 3-6 GHz	
Calibration date:	January 21, 2020	D	BNV U2-02-2	N _Q
	-		he physical units of measurements (SI). wing pages and are part of the certificate.	
All calibrations have been conducte	ed in the closed laborato	ory facility: environment tempera	ture (22 \pm 3)°C and humidity < 70%.	
Calibration Equipment used (M&TE	E critical for calibration)			
Primary Standards	1D #	Cal Date (Certificate No.)	Scheduled Calibration	
Power meter NRP	SN: 104778	03-Apr-19 (No. 217-02892/02	2893) Apr-20	
Power sensor NRP-Z91	SN: 103244	03-Apr-19 (No. 217-02892)	Apr-20	
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02893)	Apr-20	
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-19 (No. 217-02894)	Apr-20	
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20	
Reference Probe EX3DV4	SN: 3503	31-Dec-19 (No. EX3-3503_D	Dec19) Dec-20	
DAE4	SN: 601	27-Dec-19 (No. DAE4-601_0		
Secondary Standards	ID #	Check Date (in house)	Scheduled Check	
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check F	Feb-19) In house check: Oct-20	
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check C	Oct-18) In house check: Oct-20	
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check C		
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check C		
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check C	•	
	Name	Function	Signature	
Calibrated by:	Jeton Kastrati	Laboratory Tech		
Approved by:	Katja Pokovic	Technical Mana	iger	
This calibration certificate shall not	be reproduced except l	n full without written approval of	issued: January 22, 2020	

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Glossarv:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions: Further details are available from the Validation Report at the end 0 of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL: The dipole is mounted with the spacer to position its feed 0 point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss: These parameters are measured with the dipole 0 positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay: One-way delay between the SMA connector and the antenna feed point. 0 No uncertainty required.
- SAR measured: SAR measured at the stated antenna input power. 0
- SAR normalized: SAR as measured, normalized to an input power of 1 W at the antenna 0 connector.
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the 0 nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.3
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3700 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.7	3.12 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.8 ± 6 %	3.05 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		and such that did

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.72 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	67.2 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.44 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg ± 19.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	51.0	3.55 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.5 ± 6 %	3.54 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	6.56 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	65.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.7 Ω - 0.4 jΩ
Return Loss	- 37.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.6 Ω + 1.9 jΩ
Return Loss	- 30.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.141 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

DASY5 Validation Report for Head TSL

Date: 21.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1067

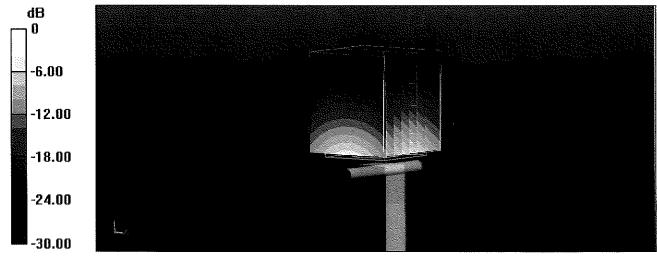
Communication System: UID 0 - CW; Frequency: 3700 MHz Medium parameters used: f = 3700 MHz; σ = 3.05 S/m; ϵ_r = 36.8; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.73, 7.73, 7.73) @ 3700 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm/Zoom Scan, dist=1.4mm

(8x8x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 70.34 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 19.4 W/kg SAR(1 g) = 6.72 W/kg; SAR(10 g) = 2.44 W/kg Smallest distance from peaks to all points 3 dB below = 8.4 mm Ratio of SAR at M2 to SAR at M1 = 72.9% Maximum value of SAR (measured) = 13.4 W/kg



0 dB = 13.4 W/kg = 11.27 dBW/kg

Impedance Measurement Plot for Head TSL

<u>Eile Y</u> jew	Channel Sweep	Calibration	Trace <u>S</u> cale	Marker	System <u>V</u>	/indow <u>H</u> e	lp		
			A	XXX			200000 GH 103.42 p 200000 GH)F -415 Hz 13.	8.742 Ω 5.91 mΩ 415 mU 161.46 °
Ch1:St	Ch 1 Avg = 20 tart 3.50000 GHz							Stop	3,90000 GHz
5.00 0.00 -5.00 -10.00 -15.00 -20.00 -25.00 -30.00 -35.00 -40.00	Ch 1 Awg = 20 tant 3.50000 GHz —				>1	3.7			7.448 dB
Status	CH 1: 511	<u> </u>	C* 1-Port		Avg=20 D	elay			LCL

DASY5 Validation Report for Body TSL

Date: 21.01.2020

Test Laboratory: SPEAG, Zurich, Switzerland

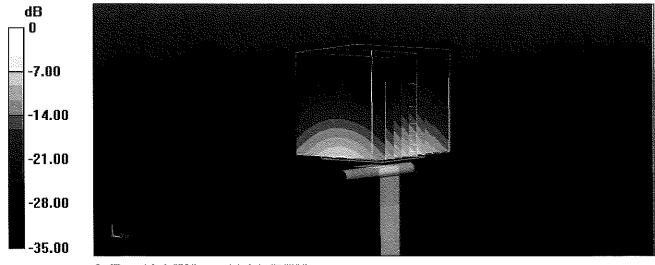
DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1067

Communication System: UID 0 - CW; Frequency: 3700 MHz Medium parameters used: f = 3700 MHz; σ = 3.54 S/m; ϵ_r = 49.5; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.31, 7.31, 7.31) @ 3700 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm/Zoom Scan , dist=1.4mm (9x9x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 63.54 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 18.1 W/kg SAR(1 g) = 6.56 W/kg; SAR(10 g) = 2.34 W/kg Smallest distance from peaks to all points 3 dB below = 7.9 mm Ratio of SAR at M2 to SAR at M1 = 74.3% Maximum value of SAR (measured) = 13.3 W/kg



0 dB = 13.3 W/kg = 11.24 dBW/kg

Impedance Measurement Plot for Body TSL

